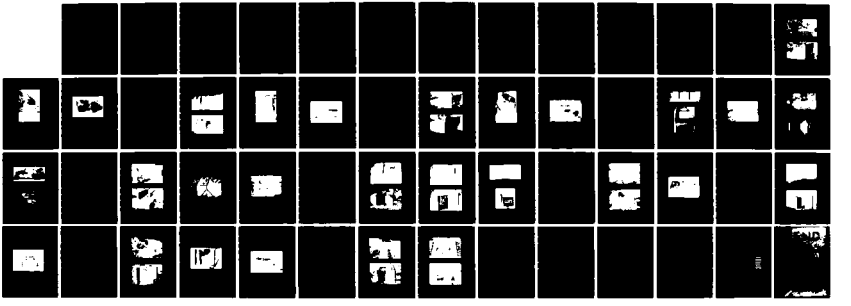
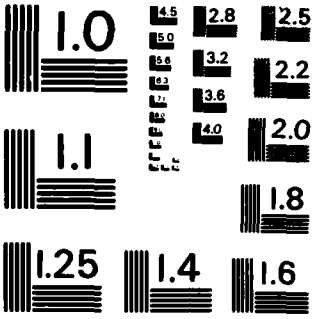
AD-A147 808 TEST TO DETERMINE THE FEASIBILITY OF CONTROLLING 1/1
FRAGMENTATION FROM THE D..(U) BALLISTIC RESEARCH LABS
ABERDEEN PROVING GROUND MD P M HOWE ET AL. OCT 84
UNCLASSIFIED BRL-MR-3387 SBI-AD-F300 494 F/G 19/4 NL





BRL

MEMORANDUM REPORT BRL-MR-3387

TEST TO DETERMINE THE FEASIBILITY OF CONTROLLING FRAGMENTATION FROM THE DETONATION OF COLLOCATED MUNITIONS

Philip M. Howe
David L. Collis

October 1984

US ARMY BALLISTIC RESEARCH LABORATORY
ABERDEEN PROVING GROUND, MARYLAND

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*New Mexico Institute of Mining and Technology, TERA Group

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Explosions, fragment impact, ammunition storage, mass detonations, fragment shielding

20. ABSTRACT (Continue on reverse side if necessary and identify by block number) (dlc)

A series of tests was run to determine the effectiveness of earthen barricades in reducing fragment hazards from the detonation of collocated stores of ammunition. Each test used three M106 8 inch artillery projectiles, detonated simultaneously, as the fragmentation source. The 8 inch projectile was chosen, as it represents essentially a worst case fragment hazard. Simultaneous detonation of a linear array of projectiles in contact (at the rotating band covers) creates an exceptionally severe fragment spray - much more severe
(continued)

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

20. ABSTRACT (continued)

than that produced by three separately detonating, non-interacting rounds. Results showed that a 2 ft thick earthen barrier will permit reduction of the hazardous fragment radius from the standard 1250 ft to well below the 170 ft which was chosen as the objective of this study.

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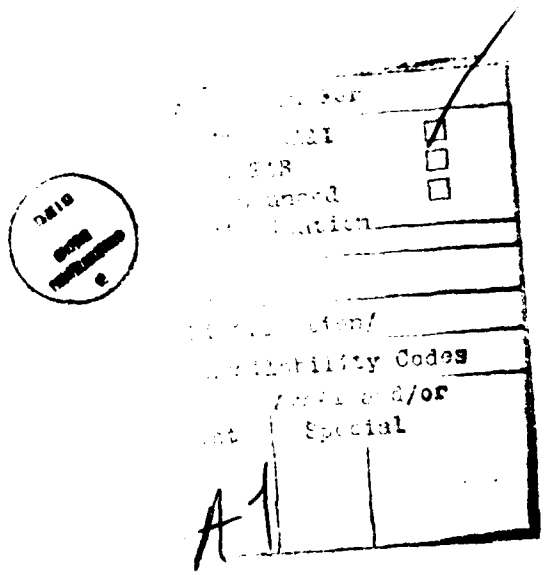


LIST OF ILLUSTRATIONS

I. INTRODUCTION

New construction of military facilities is subject to Department of Defense Explosive Safety Board review and must comply with the intent of DOD Standard 5154.4s, which specifies explosive safety quantity-distance standard. Failure to generate solutions which comply with these criteria will either delay or prevent the construction of needed facilities. The current criteria which form the limits of the quantity-distance criteria are: (1) a blast overpressure not to exceed a specified peak pressure (1 psi for inhabited buildings, 2.3 psi for R&D facilities involving explosive operations), and (2) hazardous fragments (defined as having 58 ft-lb (78.6 J) or more energy not to exceed a density of more than one per 600 sq ft (55.7 square meters). The arcs associated with these criteria are not intended to provide absolute safety, but are intended to provide an acceptably low level of risk to personnel and material.

The construction of facilities to house explosives operations can follow different design philosophies. One approach involves using sufficiently robust construction that, in the event of an explosion, the structure will survive the blast loading, will prevent excessive blast overpressures external to the building, and will prevent escape of hazardous fragments. If no other alternative is possible, this is an excellent way to go. However, for significant amounts of explosive, the material and structural requirements can become prohibitively high in cost. Under these circumstances, a feasible approach is to design the buildings without the constraint that the buildings survive the blast loading. Explosive safety criteria can still be met if the building prevents the escape of hazardous primary fragments, if the building, in the collapse process, does not itself become a source of secondary hazardous fragments, and if the blast overpressures are not excessive. This latter approach offers the significant advantage that it is generally much, much less expensive to construct buildings using this approach than buildings which completely contain fragments and blast. However, this approach suffers from the fact that engineering guidelines for construction are not readily available.

For the facilities of interest, the blast criteria could be met by limiting explosion size. No attempt was made to take advantage of blast focussing, and buildings could be made of any economically and functionally feasible construction, with the provison that sufficient shielding be provided to prevent escape of an unacceptable number of hazardous fragments. To this end, a series of tests was conducted to establish an acceptable thickness of shielding.

II. SHIELDING TESTS

Soils such as clays and wet sands are low resistance materials which require several projectile lengths of penetration to exert any strong effect upon the velocity of penetration. Gravels offer slightly more resistance, but

the differences are not strong. The trajectories of spherical or chunky fragments can be predicted with reasonable accuracy using the Poncelet[1] relation or the Sandia Laboratory's equations.[2] However, fragmenting artillery shells generate a large number of long, sliver-like fragments. These fragments are inherently unstable in penetration, and predictions of required material thickness for stopping are not currently possible. Our problem is complicated further by the fact that the distribution of fragment masses and velocities is quite broad. This latter result arises partially from the nature of the fragmentation process for the individual round and partially from the interaction between rounds, which leads to extremely large fragments travelling at very high velocities (velocities of the order of twice the fragment velocities generated by detonation of an individual round). We therefore decided to rely on results of experimental testing rather than attempt to use theoretical approaches.

Experiments were conducted using three M106 8 inch artillery shells as the source of fragmentation. In each test, the three rounds were arranged collinearly, with the separation between rounds determined by the rotating band covers. All three rounds were detonated simultaneously, to insure the worst possible fragmentation hazard. Shield materials were placed 12 ft (3.6 meters) from the centerline of the three rounds, as this distance is commensurate with the planned distances from explosive source to walls in the proposed building configurations. A 0.62 inch (1.6 mm) steel witness plate was used in each test to determine the number of fragments (see figures for schematics of test configurations). Results are summarized in Table 1 and are outlined in Figures 1-10.

III. DISCUSSION

As noted earlier, the most hazardous fragments are generated in the interaction zones between rounds in contact. Powell, et al,[3] in their studies of the fragmentation generated by detonation of stacks of ammunition, showed quite clearly that the number of high velocity fragments generated by detonation of a stack of ammunition is directly proportional to the number of interaction zones. Our tests, involving three 8 inch projectiles in a row, faithfully reproduce the worst fragmentation hazards for a single pallet of 8 inch projectiles. The fragmentation hazards associated with larger arrays of 8 inch projectiles can easily be inferred by enumerating the interaction zones.

---

[1] W. Allen. et al, "Dynamics of a Projectile Penetrating Sand, Part I," J. Appl.Phys. 28, pp 370-376; "Dynamics of a Projectile Penetrating Sand, Part II," J. Appl. Phys. 28, pp 1331-1335.

[2] C. Yound, "Low Velocity Earth Penetration Study," Wendover Operation, Sandia Labs SC-TM-66-2611, Sandia, NM (1967).

[3] J. Powell, et al, "Fragment Hazard Investigation Program: Natural Communication Detonation of 155 mm Projectiles," NSWC TR-81-54, Naval Surface Weapons Center (1981).

Examination of the test data shows that several of the tested shield configurations provide acceptable fragment protection, given that the hazardous fragment distance can be as large as 170 ft (50 meters) for the facilities of interest. Thus, it appears that a 2 ft (61.0 cm) thick earth barrier, with a steel retaining wall as thin as 0.016 inches (0.4 mm) thick, will provide adequate fragment protection for simultaneous detonation of three 8 inch M106 projectiles. By inference, the same statement can be made for two pallets of 8 inch projectiles, or two pallets of 155 mm projectiles, or for any other munitions array with less severe fragmentation.

IV. CONCLUSIONS

We conclude, on the basis of a small series of tests, that relatively inexpensive and relatively thick earth barriers are adequate to reduce fragment hazards resulting from detonation of arrays of large caliber projectiles.

ACKNOWLEDGEMENTS

This effort was performed for Mr. Richard Baily, Materiel Testing Directorate, Aberdeen Proving Ground, Maryland, and was supported with funds provided by Materiel Testing Directorate.

Table 1. FRAGMENTATION TESTS

Test No.	Wall Front	Wall Back	Earth Bag Wall	Earth Fill	Results
JBA1122A3	0.4 mm corrugated steel		30.5 cm	-	Witness sheet found in two pieces, numerous holes.
JBA1123A3	0.4 mm corrugated steel		91.4 cm	-	Witness sheet received holes at top and bottom edges
JBA1128A3	0.4 mm corrugated steel		61.0 cm	-	Witness sheet received several holes at left center.
JBA1129A3	4.1 cm wood/ 4.1 cm wood		-	61.0 cm	Witness sheet received three holes.
JBA1130A3	14.0 cm light concrete 0.64 cm plywood sheeting		-	-	Witness sheet found in two pieces, numerous holes.
JBA1130B3	4.1 cm wood/ 4.1 cm wood		-	76.2 cm	Witness sheet received one hole in upper right corner.
JBA1201A3	43.2 cm light concrete 0.64 cm plywood sheeting		-	-	Witness sheet received numerous holes.
JBA1201B3	0.64 cm steel/ 0.64 cm steel		-	45.7 cm	Witness sheet received one hole at lower left edge.
JBA1202A3	20.3 cm reinforced concrete/0.64 cm plywood sheeting		30.5 cm	-	Witness sheet undamaged.
JBA1202B3	0.32 cm steel/ 0.32 cm steel		-	61.0 cm	Witness sheet received one hole at upper center.

TEST: JBA1122A3
DATE: 22 NOVEMBER 1983
TIME: 12:05 MST

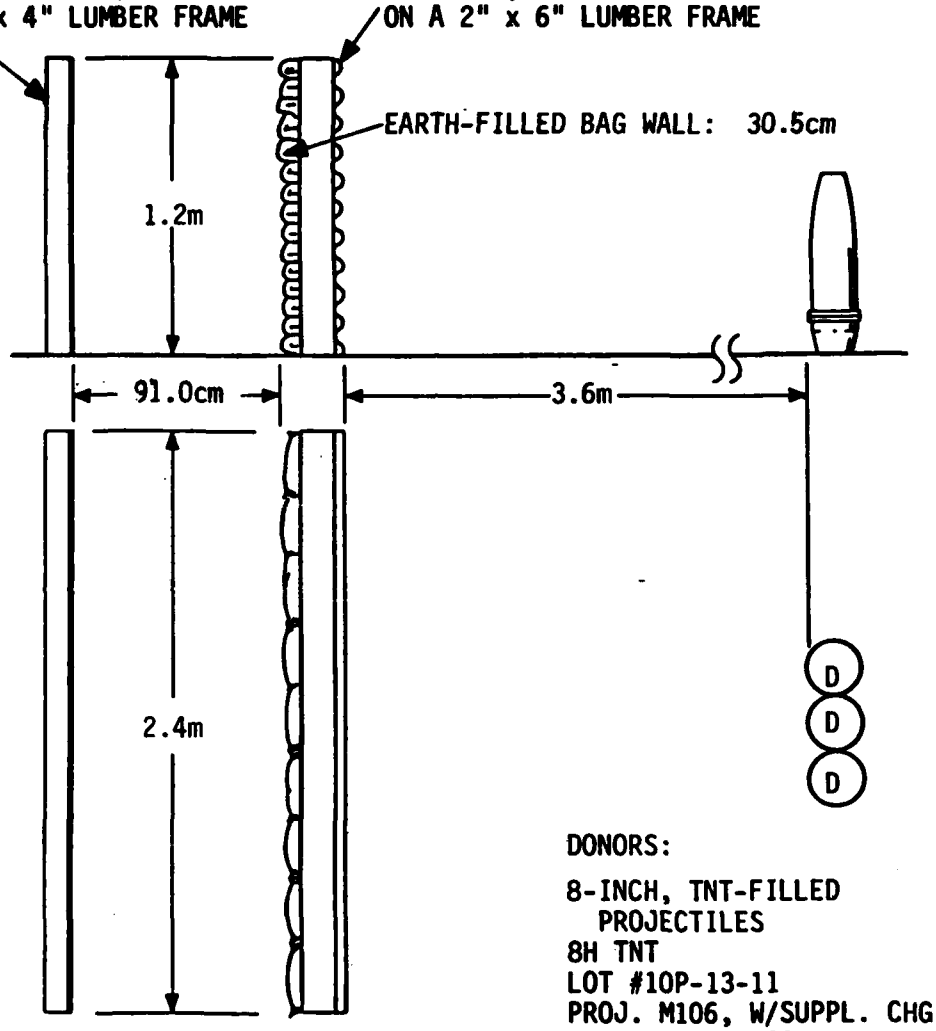
MAGAZINE STORAGE TEST

WITNESS SHEET:

1.6mm TK STEEL, 1.2m x 2.4m
ON 2" x 4" LUMBER FRAME

CORRUGATED STEEL ROOFING MATERIAL:

0.4mm TK, 1.2m x 2.4m
ON A 2" x 6" LUMBER FRAME



DONORS:

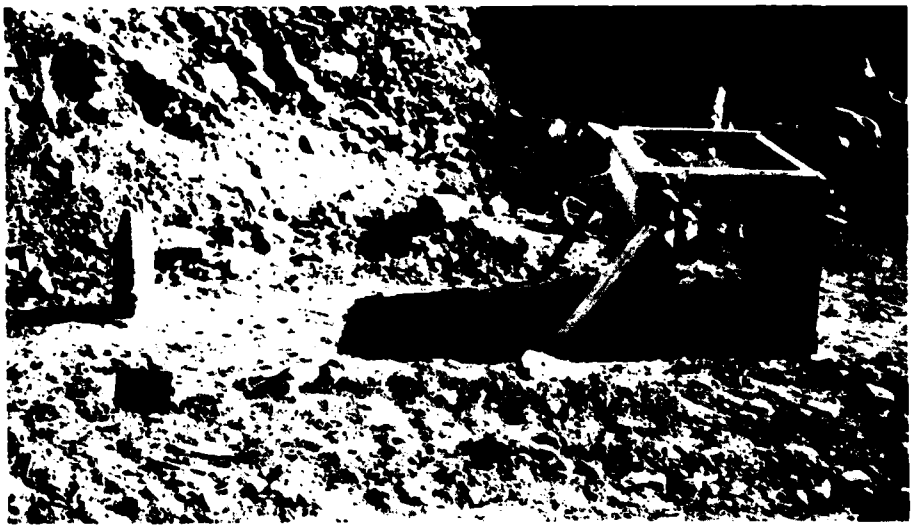
8-INCH, TNT-FILLED
PROJECTILES
8H TNT
LOT #10P-13-11
PROJ. M106, W/SUPPL. CHG.
D680 USH-1-222
59-8-IN-M106, 3 each

RESULTS:

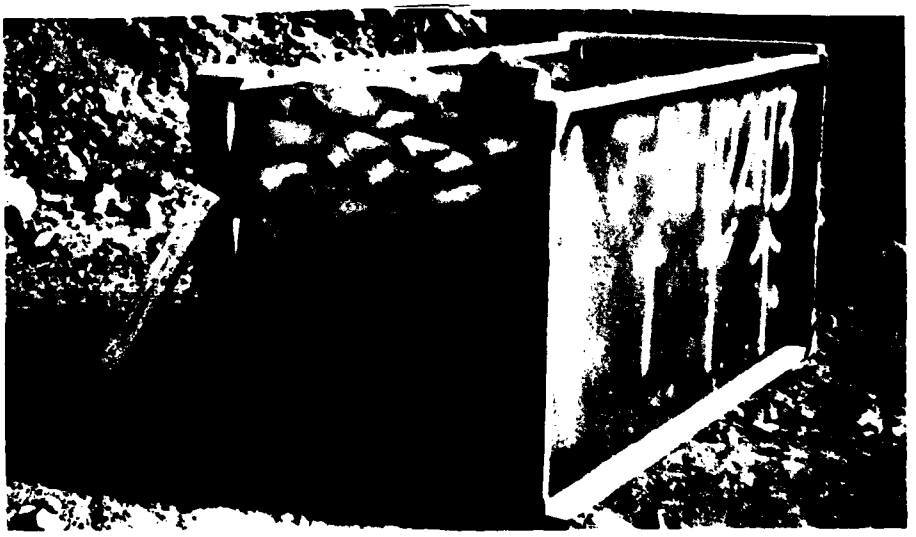
TARGET WALL DISINTEGRATED. WITNESS SHEET RECOVERED IN TWO PIECES WITH NUMEROUS FRAGMENT PERFORATIONS. DAMAGE CONCENTRATED IN CENTER OF SHEET.

Figure 1. Test JBA1122A3

TEST: JBA1122A3
DATE: 22 NOVEMBER 1983
TIME: 12:05 MST



OVERALL VIEW SHOWING SETUP - BEFORE TEST



CLOSEUP OF TARGET WALL AND WITNESS SHEET
BEFORE TEST

Figure 1. Test JBA1122A3 (continued)

TEST: JBA1122A3
DATE: 22 NOVEMBER 1983
TIME: 12:05 MST

CLOSEUP OF TARGET WALL CONSTRUCTION DETAIL
BEFORE TEST

Figure 1. TEST JBA1122A3 (continued)

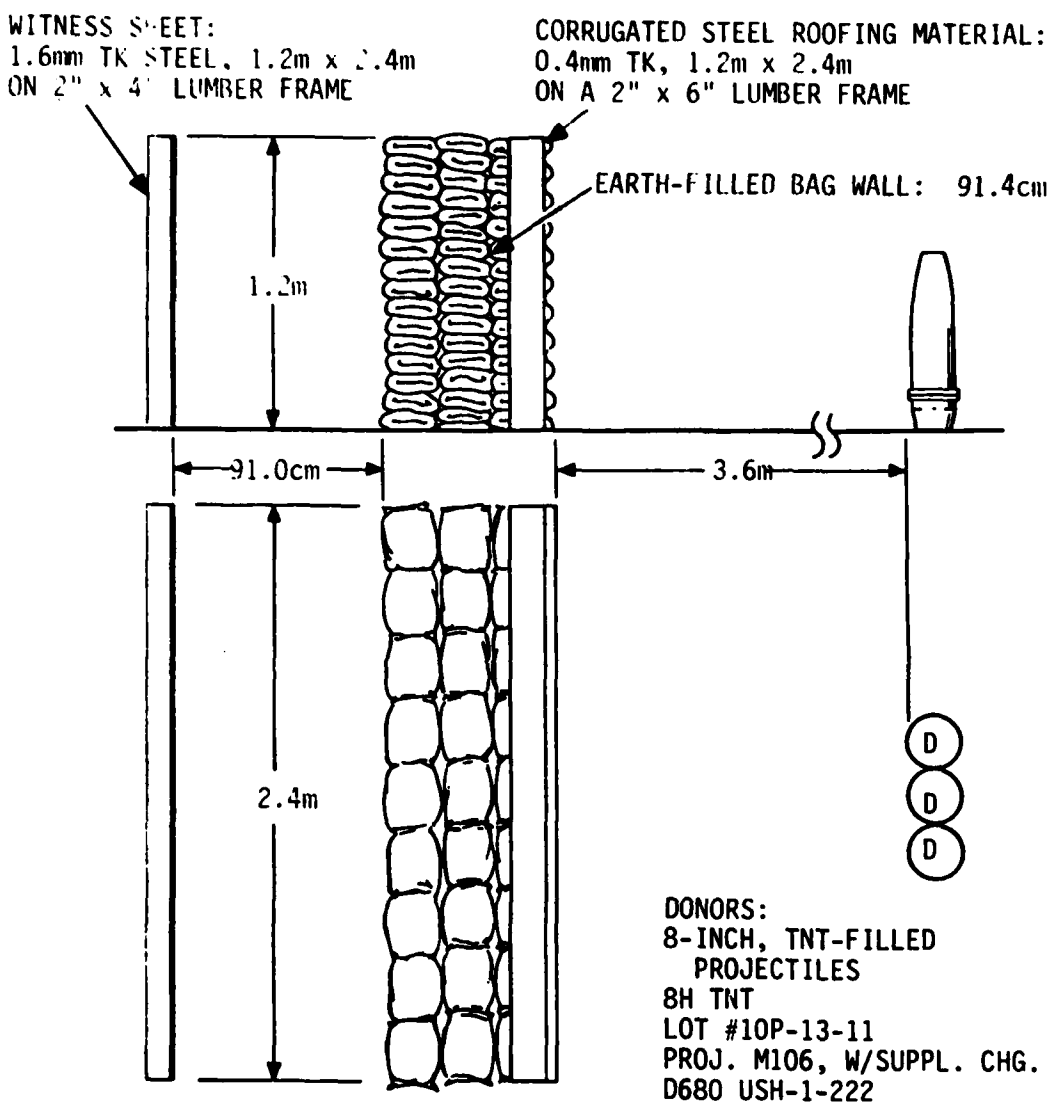
TEST: JBA1122A3
DATE: 22 NOVEMBER 1983
TIME: 12:05 MST

WITNESS SHEET DAMAGE - AFTER TEST

Figure 1. Test JBA1122A3 (continued)

TEST: JBA1123A3
DATE: 23 NOVEMBER 1983
TIME: 08:45 MST

MAGAZINE STORAGE TEST



DONORS:
8-INCH, TNT-FILLED
PROJECTILES
8H TNT
LOT #10P-13-11
PROJ. M106, W/SUPPL. CHG.
D680 USH-1-222
59-8-IN-M106, 3 EACH

RESULTS:

TARGET WALL DISINTEGRATED. WITNESS SHEET RECOVERED WITH SLIGHT DAMAGE. SEVEN PERFORATIONS ALONG TOP AND BOTTOM EDGE. APPEARED THAT MOST OF THE PERFORATIONS WERE FROM LOW VELOCITY FRAGMENTS.

Figure 2. Test JBA1123A3

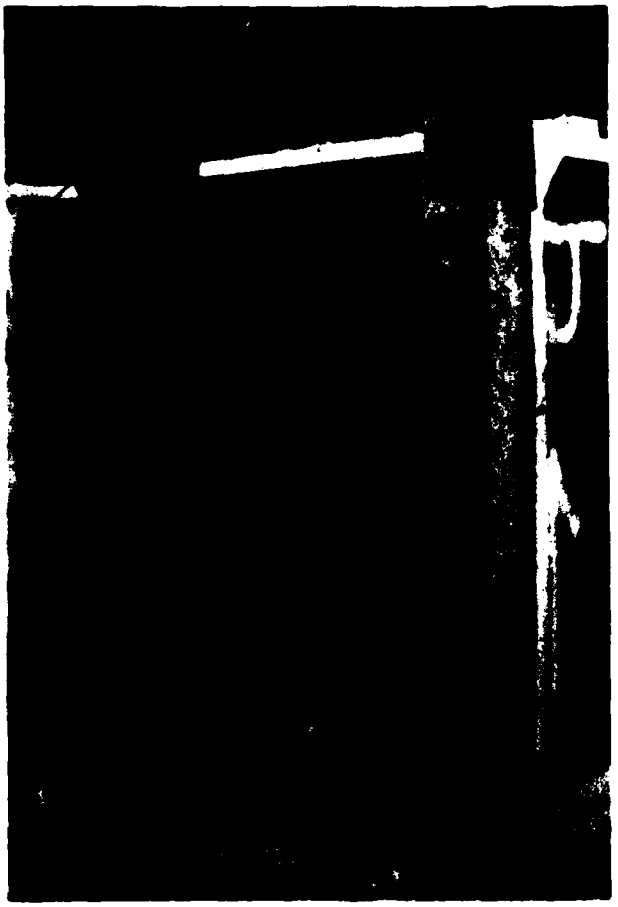
TEST: JBA1123A3
DATE: 23 NOVEMBER 1983
TIME: 08:45 MST

OVERALL VIEW SHOWING SETUP - BEFORE TEST

CLOSEUP OF TARGET WALL AND WITNESS SHEET - BEFORE TEST

Figure 2. Test JBA1123A3 (continued)

TEST: JBA1123A3
DATE: 23 NOVEMBER 1983
TIME: 08:45 MST



CLOSEUP OF TARGET WALL CONSTRUCTION DETAIL
BEFORE TEST

Figure 2. Test JBA1123A3 (continued)

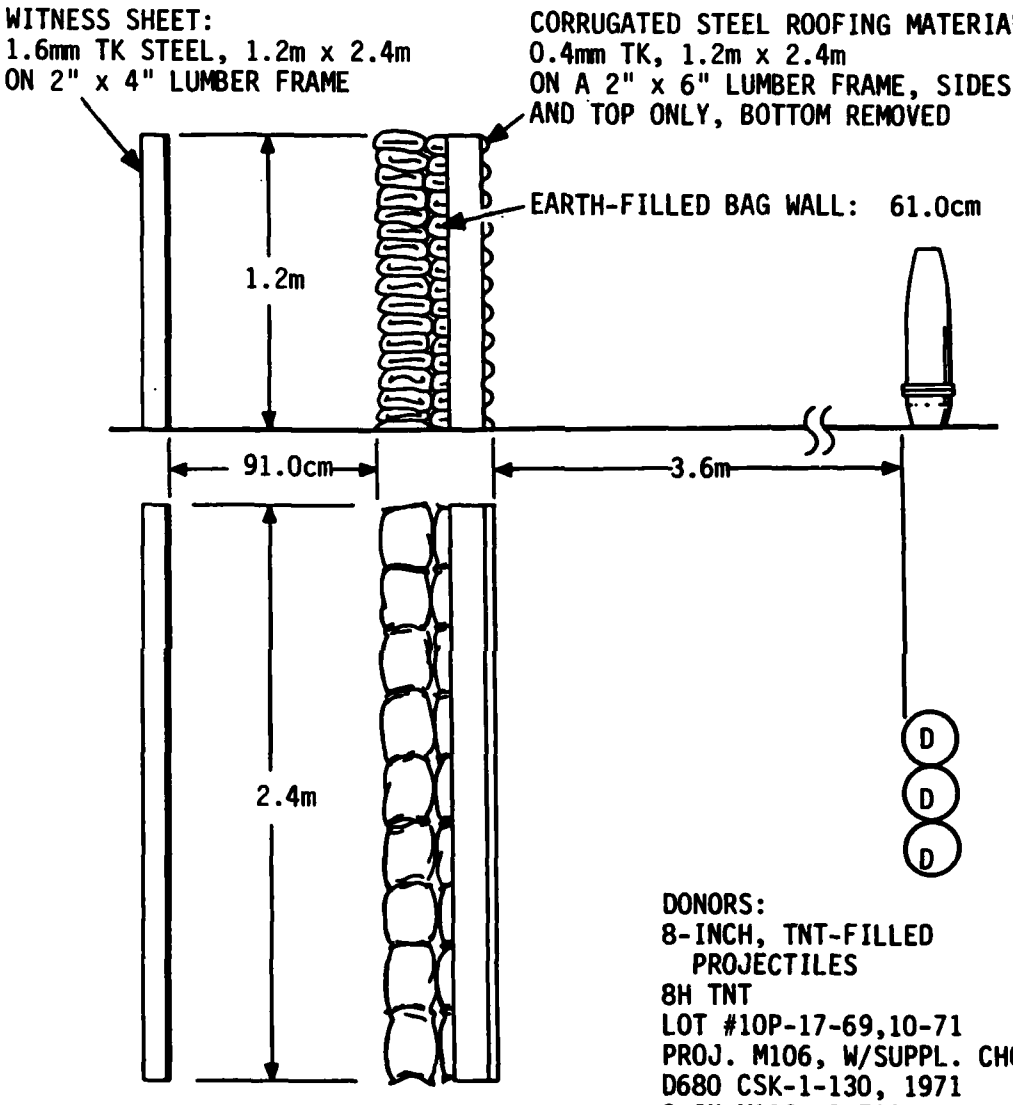
TEST: JBA1123A3
DATE: 23 NOVEMBER 1983
TIME: 08:45 MST

WITNESS SHEET DAMAGE - AFTER TEST

Figure 2. Test JBA1123A3 (continued)

TEST: JBA1128A3
DATE: 28 NOVEMBER 1983
TIME: 09:53 MST

MAGAZINE STORAGE TEST



DONORS:
8-INCH, TNT-FILLED
PROJECTILES
8H TNT
LOT #10P-17-69,10-71
PROJ. M106, W/SUPPL. CHG.
D680 CSK-1-130, 1971
8-IN-M106, 3 EACH

RESULTS:

TARGET WALL DISINTEGRATED. WITNESS SHEET RECOVERED WITH NUMEROUS FRAGMENT PERFORATIONS AND IMPACTS. SOME IMPACT DENTS HAD CRACKS IN CENTER.

Figure 3. Test JBA1128A3

TEST: JBA1128A3
DATE: 28 NOVEMBER 1983
TIME: 09:53 MST

OVERALL VIEW SHOWING SETUP - BEFORE TEST

CLOSEUP OF TARGET WALL AND WITNESS SHEET - BEFORE TEST

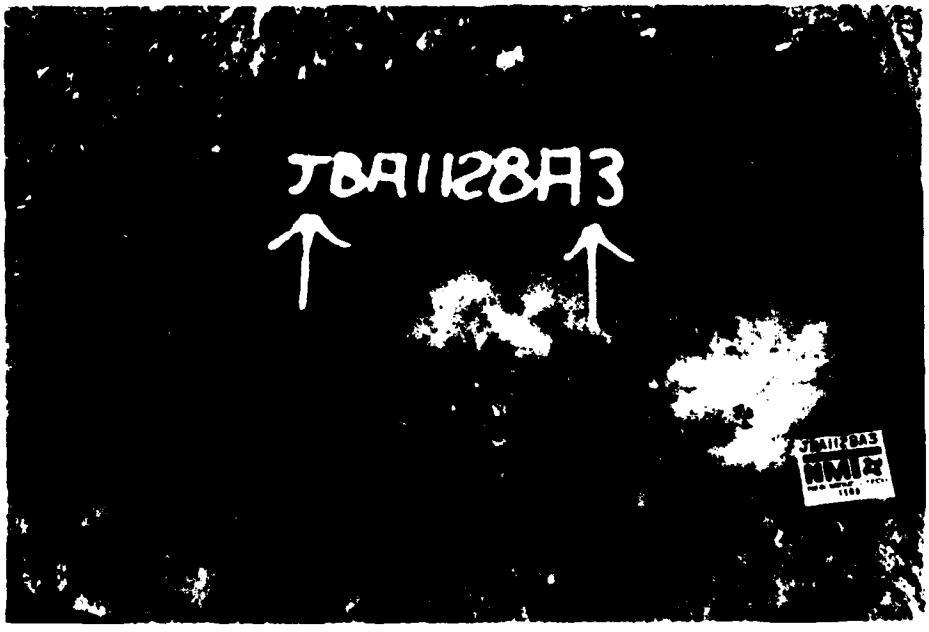
Figure 3. Test JBA1128A3 (continued)

TEST: JBA1128A3
DATE: 28 NOVEMBER 1983
TIME: 09:53 MST

CLOSEUP OF TARGET WALL CONSTRUCTION DETAIL
BEFORE TEST

Figure 3. Test JBA1128A3 (continued)

TEST: JBA1128A3
DATE: 28 NOVEMBER 1983
TIME: 09:53 MST

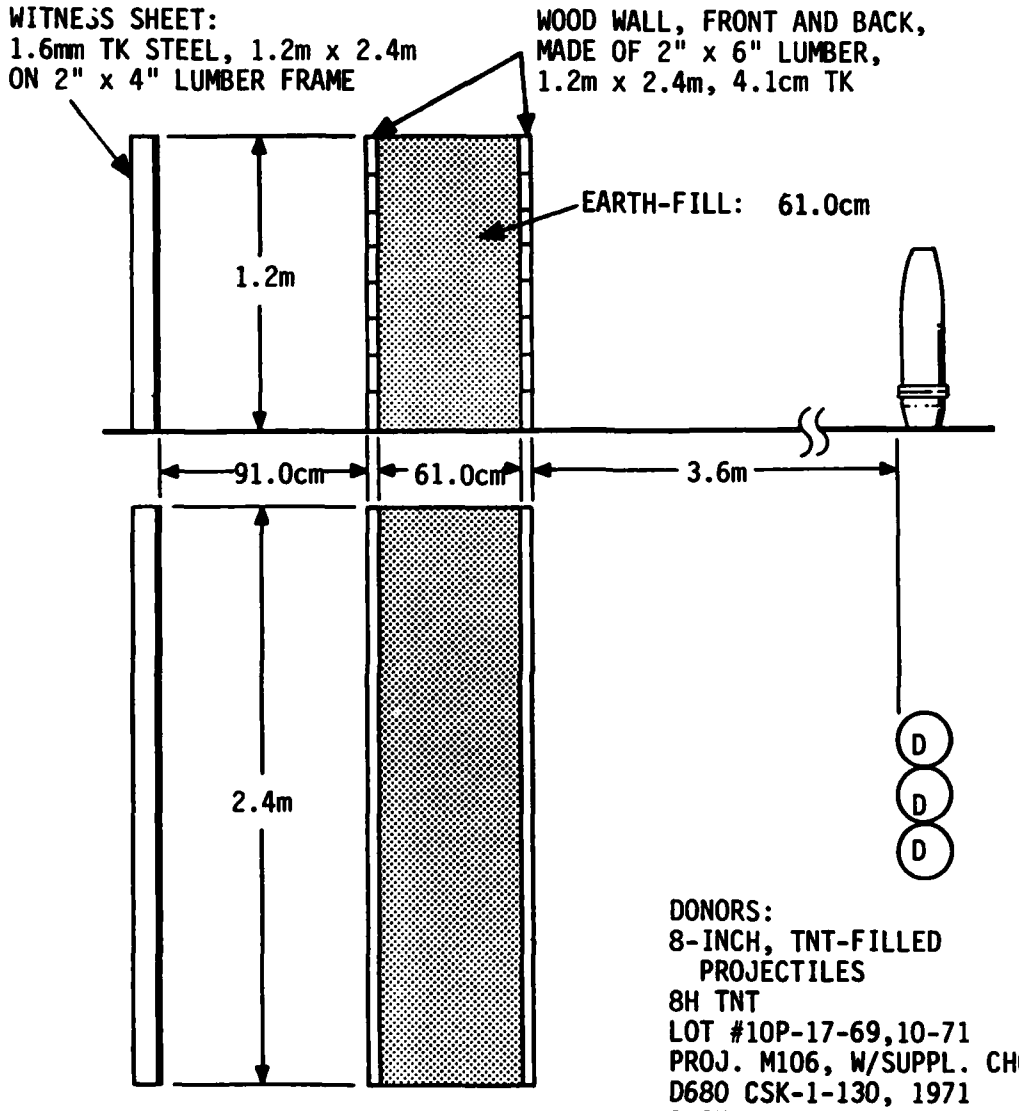


WITNESS SHEET DAMAGE - AFTER TEST

Figure 3. Test JBA1128A3 (continued)

TEST: JBA1129A3
DATE: 29 NOVEMBER 1983
TIME: 16:18 MST

MAGAZINE STORAGE TEST



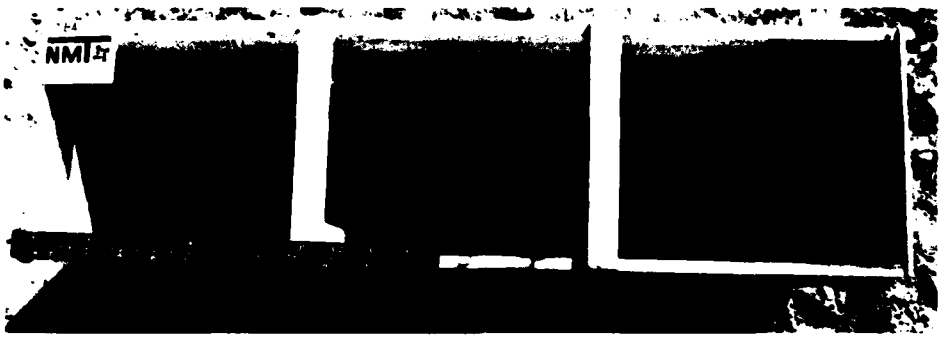
DONORS:
8-INCH, TNT-FILLED
PROJECTILES
8H TNT
LOT #10P-17-69,10-71
PROJ. M106, W/SUPPL. CHG.
D680 CSK-1-130, 1971
8-IN-M106, 3 EACH

RESULTS:

TARGET WALL DISINTEGRATED. WITNESS SHEET RECOVERED WITH THREE FRAGMENT PERFORATIONS AND ONE PARTIAL PENETRATION.

Figure 4. Test JBA1129A3

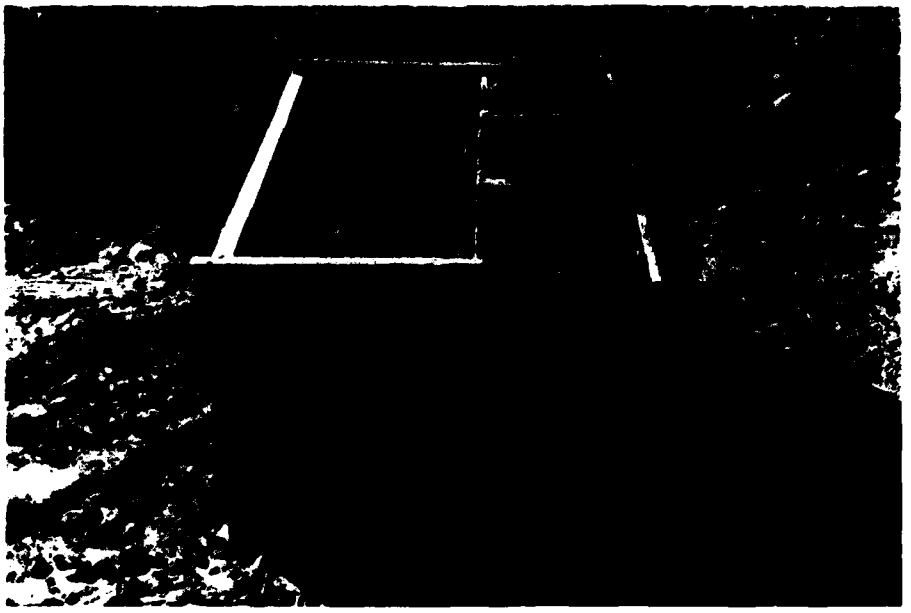
TEST: JBA1129A3
DATE: 29 NOVEMBER 1983
TIME: 16:18 MST



CLOSEUP OF INTERIOR CONSTRUCTION DETAIL OF TARGET WALL,
PRIOR TO EARTH FILL - BEFORE TEST

Figure 4. Test JBA1129A3 (continued)

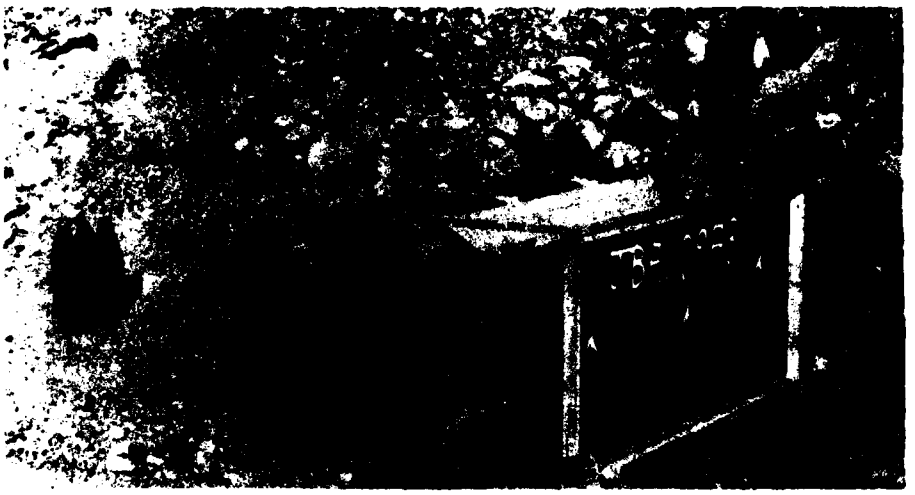
TEST: JBA1129A3
DATE: 29 NOVEMBER 1983
TIME: 16:18 MST



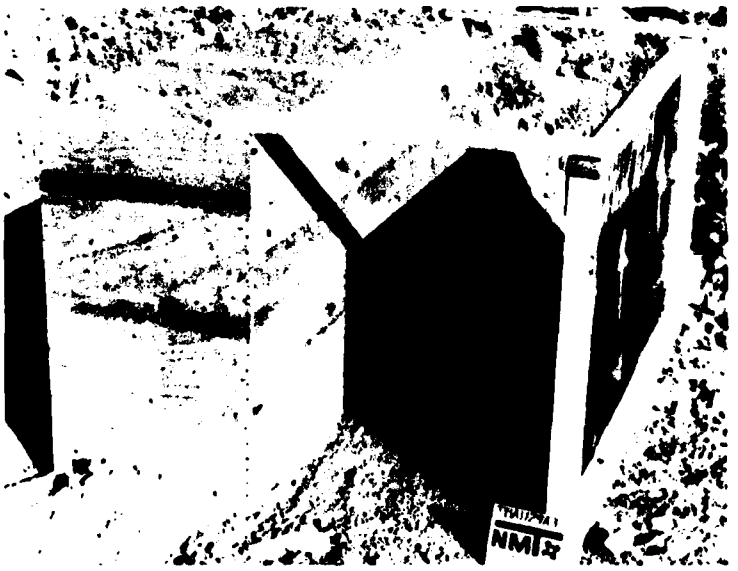
CLOSEUP OF TARGET WALL CONSTRUCTION DETAIL
AFTER EARTH FILL WAS ADDED - BEFORE TEST

Figure 4. Test JBA1129A3 (continued)

TEST: JBA1129A3
DATE: 29 NOVEMBER 1983
TIME: 16:18 MST



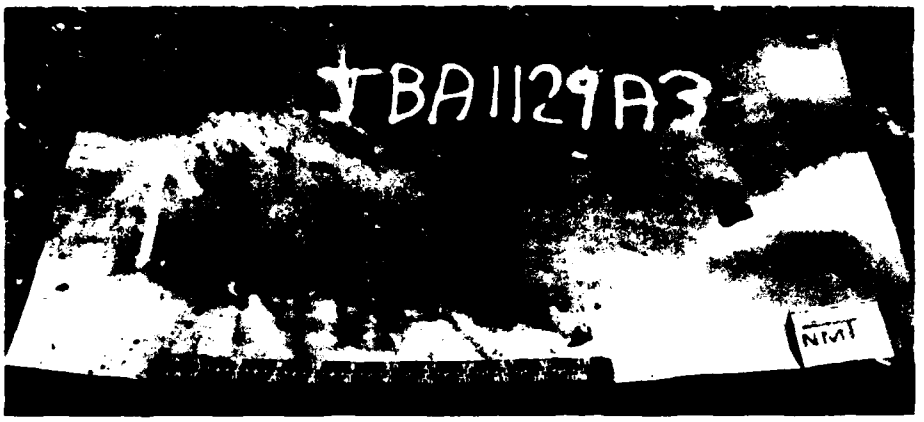
OVERALL VIEW SHOWING SETUP - BEFORE TEST



CLOSEUP OF TARGET WALL AND WITNESS SHEET - BEFORE TEST

Figure 4. Test JBA1129A3 (continued)

TEST: JBA1129A3
DATE: 29 NOVEMBER 1983
TIME: 16:18 MST



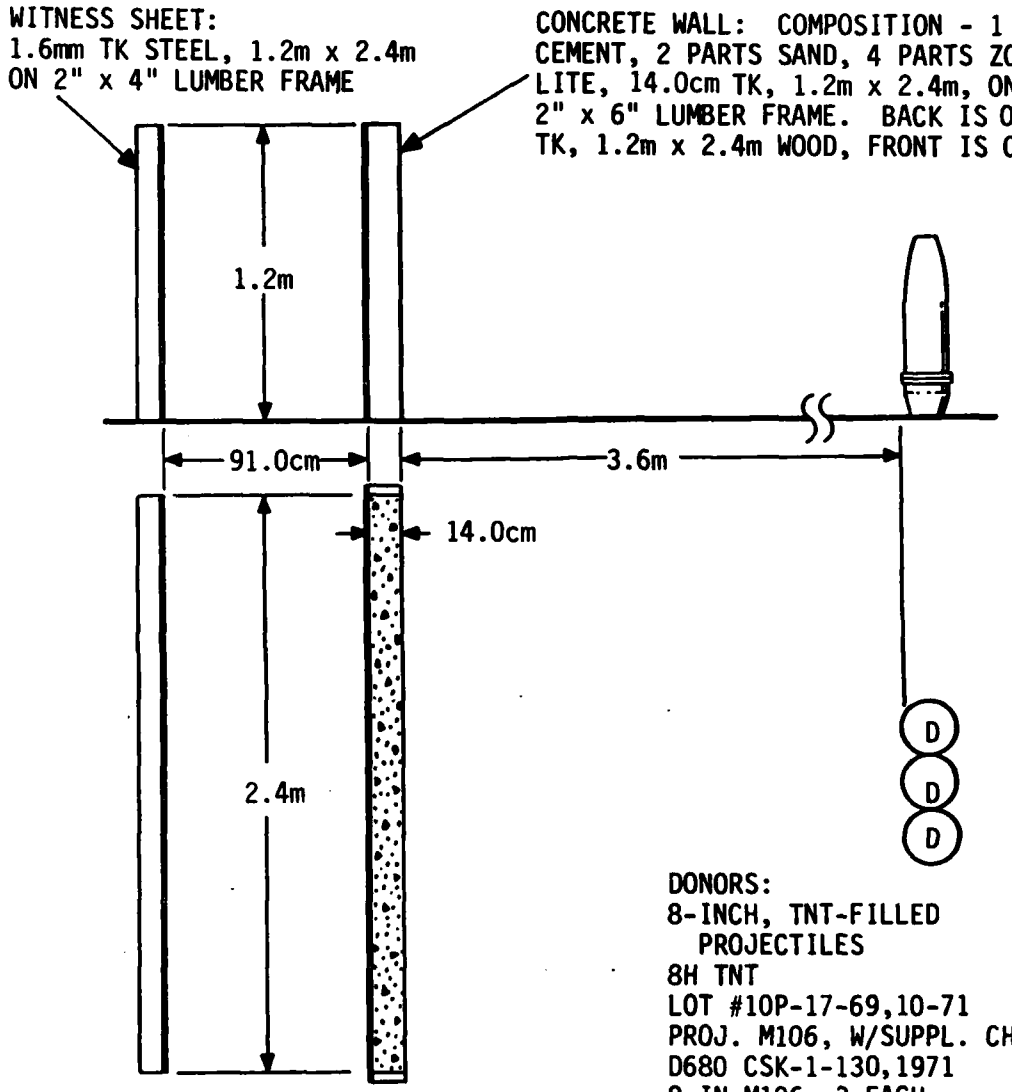
WITNESS SHEET DAMAGE - AFTER TEST

CLOSEUP OF PARTIAL PENETRATION OF WITNESS SHEET
AFTER TEST

Figure 4. Test JBA1129A3 (continued)

TEST: JBA1130A3
DATE: 30 NOVEMBER 1983
TIME: 11:29 MST

MAGAZINE STORAGE TEST



DONORS:
8-INCH, TNT-FILLED
PROJECTILES
8H TNT
LOT #10P-17-69,10-71
PROJ. M106, W/SUPPL. CHG.
D680 CSK-1-130,1971
8-IN-M106, 3 EACH

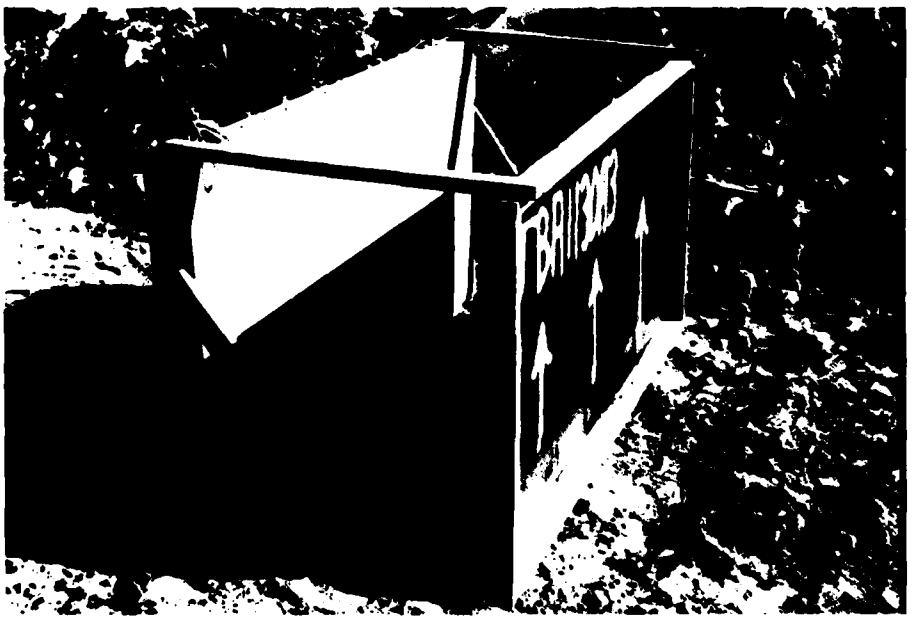
RESULTS:

TARGET WALL DISINTEGRATED. WITNESS SHEET RECOVERED IN TWO PIECES WITH NUMEROUS FRAGMENT PERFORATIONS.

Figure 5. Test JBA1130A3

TEST: JBA1130A3
DATE: 30 NOVEMBER 1983
TIME: 11:29 MST

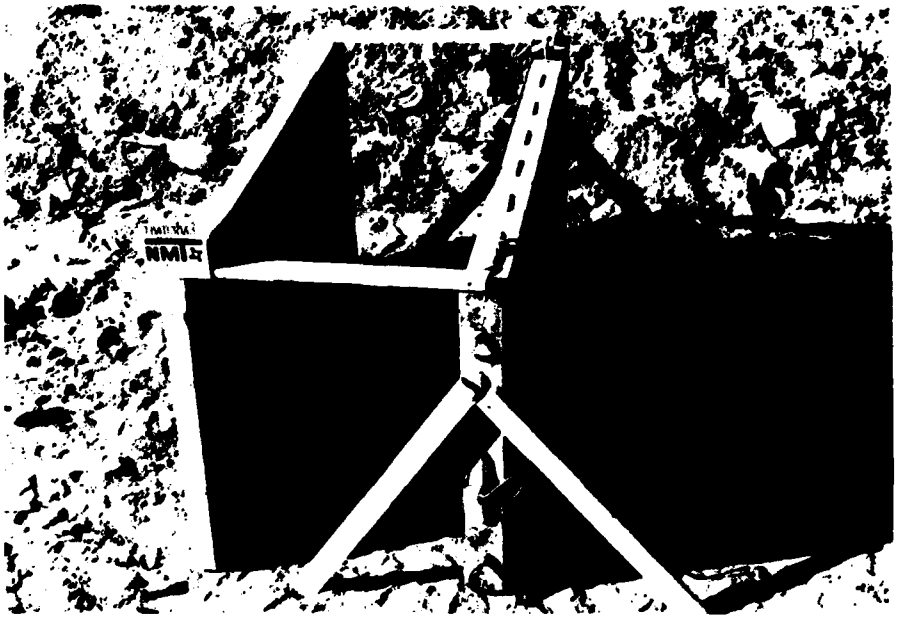
OVERALL VIEW SHOWING SETUP - BEFORE TEST



CLOSEUP OF TARGET WALL AND WITNESS SHEET - BEFORE TEST

Figure 5. Test JBA1130A3 (continued)

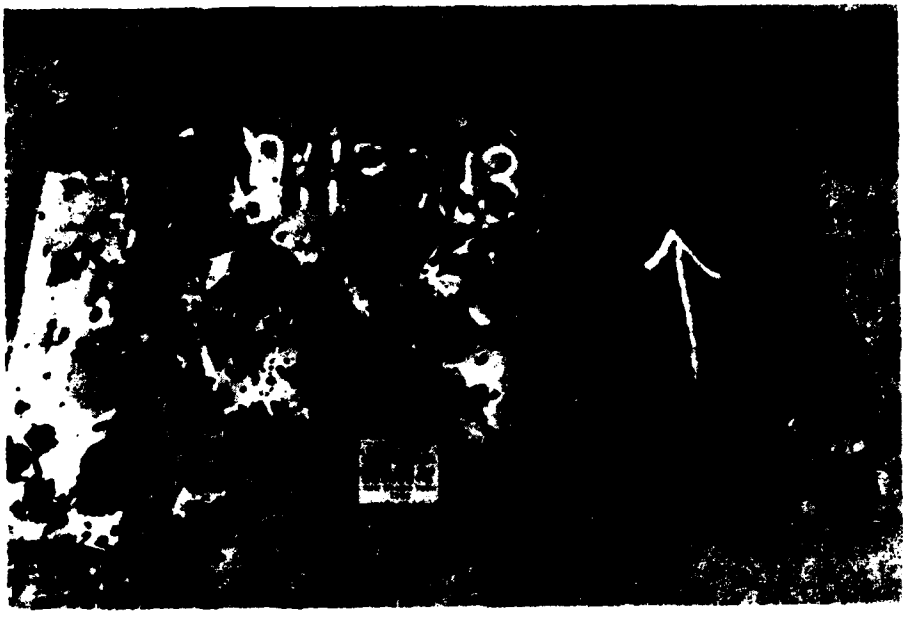
TEST: JBA1130A3
DATE: 30 NOVEMBER 1983
TIME: 11:29 MST



CLOSEUP OF TARGET WALL CONSTRUCTION DETAIL - BEFORE TEST

Figure 5. Test JBA1130A3 (continued)

TEST: JBA1130A3
DATE: 30 NOVEMBER 1983
TIME: 11:29 MST

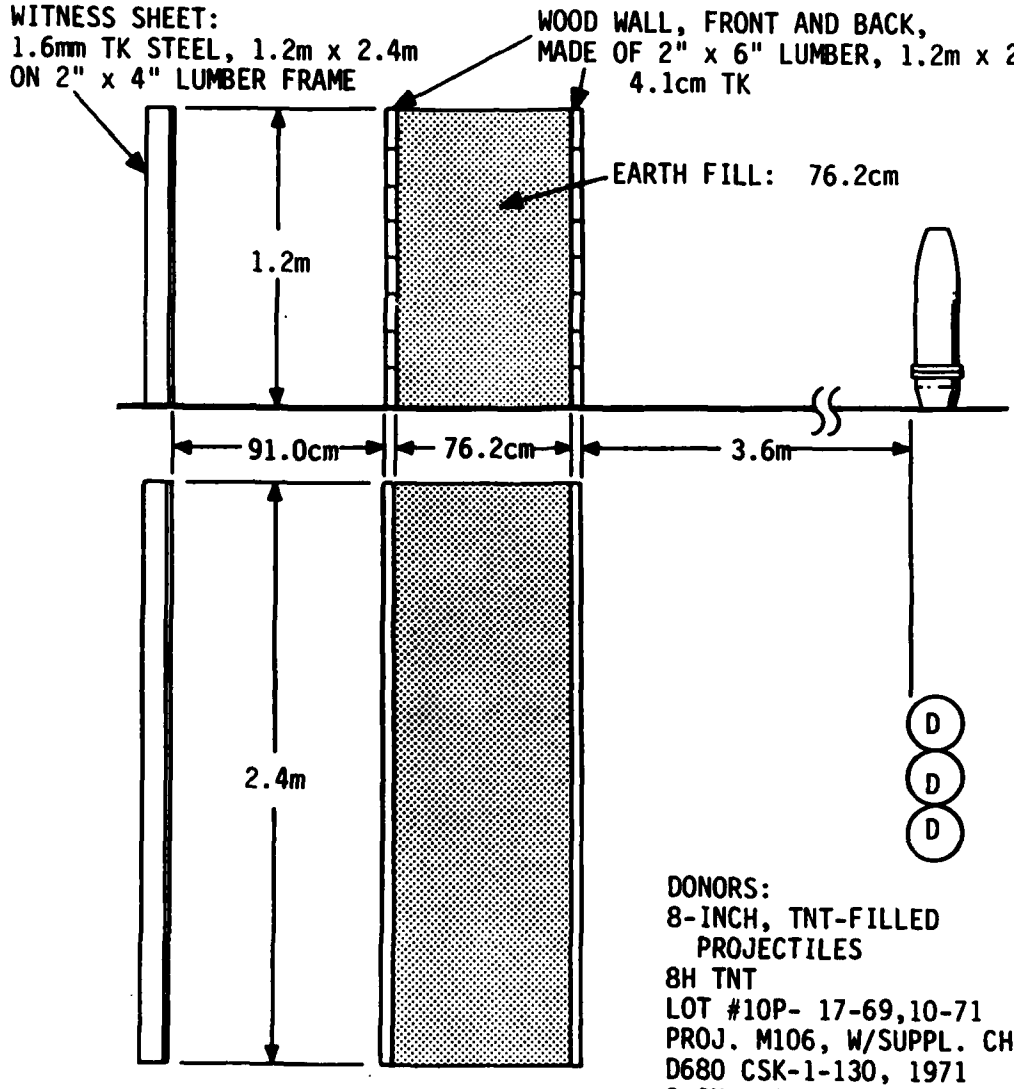


WITNESS SHEET DAMAGE - AFTER TEST

Figure 5. Test JBA1130A3 (continued)

TEST: JBA1130B3
DATE: 30 NOVEMBER 1983
TIME: 16:15 MST

MAGAZINE STORAGE TEST



DONORS:
8-INCH, TNT-FILLED
PROJECTILES
8H TNT
LOT #10P- 17-69,10-71
PROJ. M106, W/SUPPL. CHG.
D680 CSK-1-130, 1971
8-IN-M106, 3 EACH

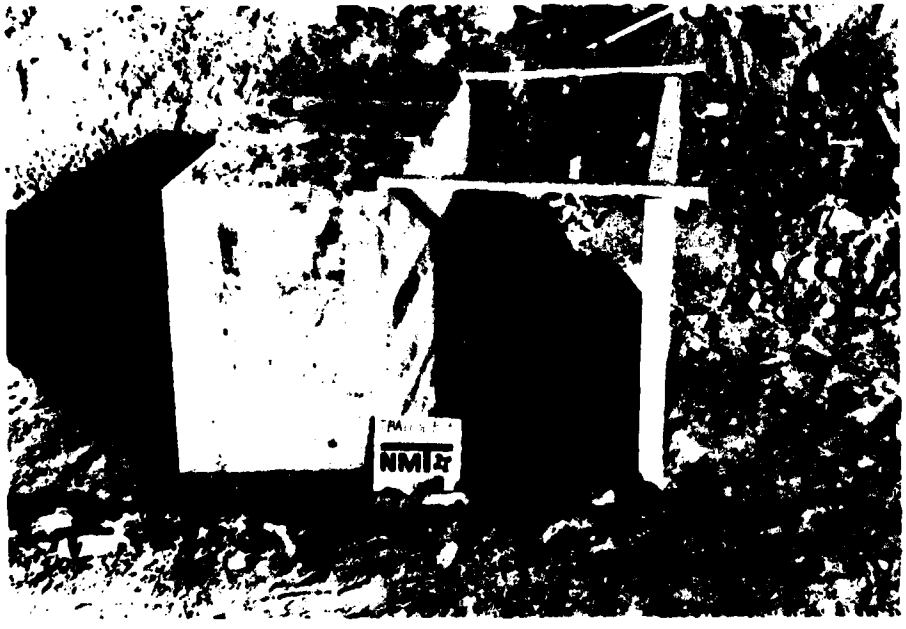
RESULTS:

TARGET WALL DISINTEGRATED. WITNESS SHEET RECOVERED WITH ONE FRAGMENT PERFORATION.

Figure 6. Test JBA1130B3

TEST: JBA1130B3
DATE: 30 NOVEMBER 1983
TIME: 16:15 MST

CLOSEUP OF INTERIOR CONSTRUCTION DETAIL OF TARGET WALL PRIOR TO EARTH FILL - BEFORE TEST

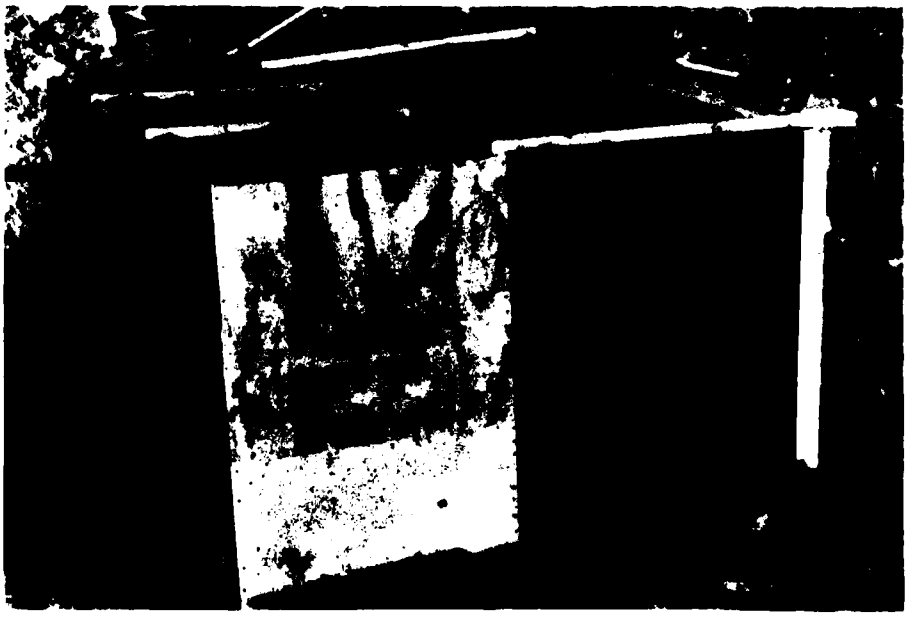


CLOSEUP OF TARGET WALL CONSTRUCTION DETAIL - AFTER EARTH FILL WAS ADDED - BEFORE TEST

Figure 6. Test JBA1130B3 (continued)

TEST: JBA1130B3
DATE: 30 NOVEMBER 1983
TIME: 16:15 MST

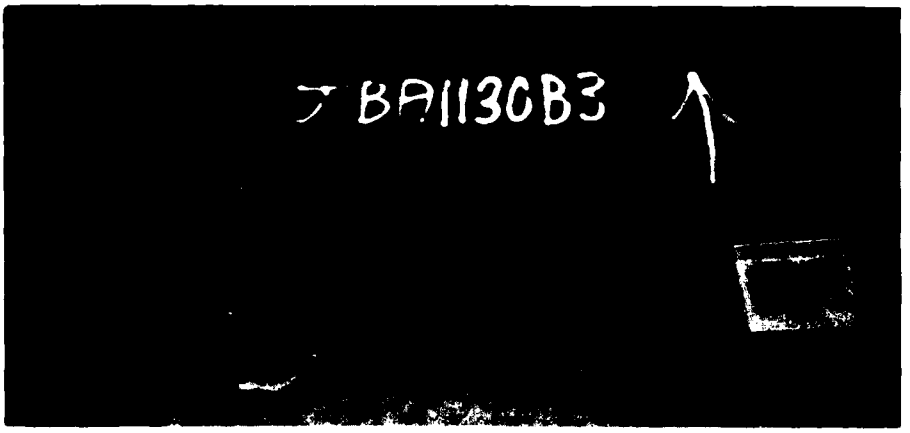
OVERALL VIEW SHOWING SETUP - BEFORE TEST



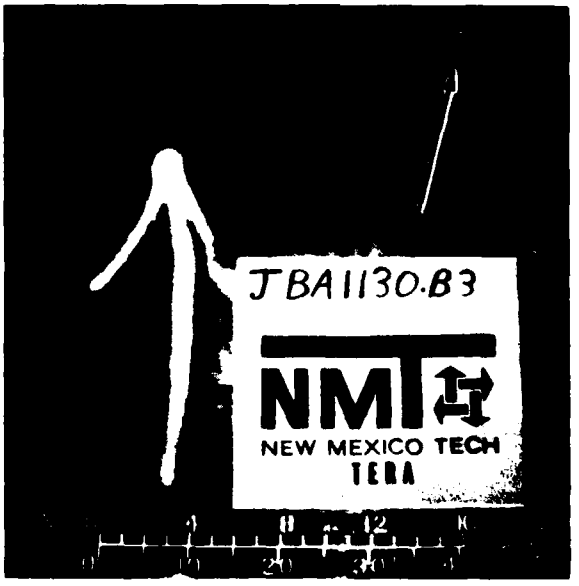
CLOSEUP OF TARGET WALL AND WITNESS SHEET - BEFORE TEST

Figure 6. Test JBA1130B3 (continued)

TEST: JBA1130B3
DATE: 30 NOVEMBER 1983
TIME: 16:15 MST



WITNESS SHEET DAMAGE - AFTER TEST



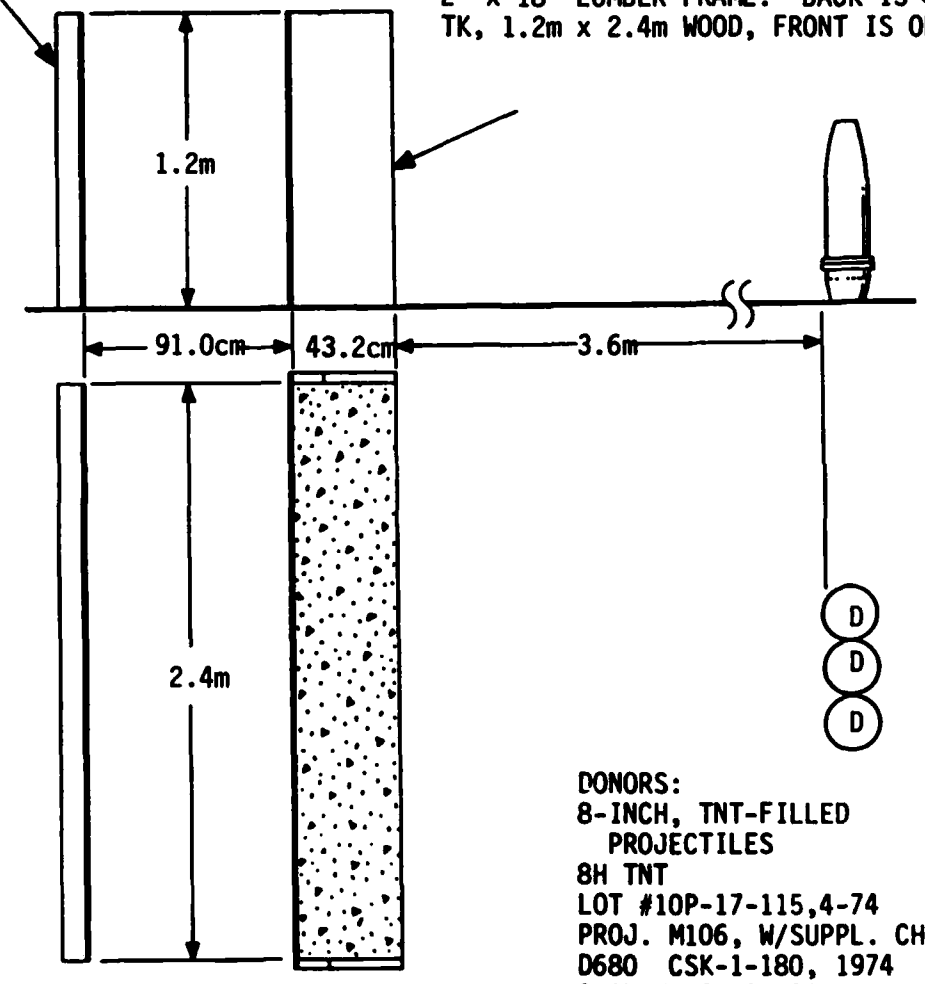
CLOSEUP OF WITNESS SHEET DAMAGE
AFTER TEST
FRAGMENT PERFORATION SHOWN BY ARROW
Figure 6. Test JBA1130B3 (continued)

TEST: JBA1201A3
DATE: 1 DECEMBER 1983
TIME: 12:00 MST

MAGAZINE STORAGE TEST

WITNESS SHEET:
1.6mm TK STEEL, 1.2m x 2.4m
ON 2" x 4" LUMBER FRAME

CONCRETE WALL: COMPOSITION - 1 PART CEMENT, 2 PARTS SAND, 4 PARTS ZONOLITE, 43.2cm TK, 1.2m x 2.4m ON A 2" x 18" LUMBER FRAME. BACK IS 0.64cm TK, 1.2m x 2.4m WOOD, FRONT IS OPEN.



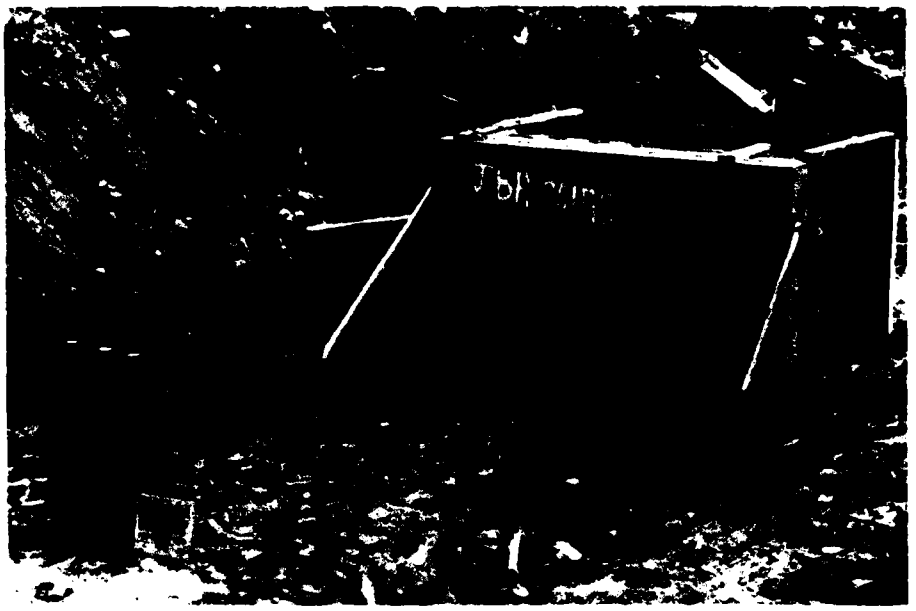
DONORS:
8-INCH, TNT-FILLED
PROJECTILES
8H TNT
LOT #10P-17-115,4-74
PROJ. M106, W/SUPPL. CHG.
D680 CSK-1-180, 1974
8-IN-M106, 3 EACH

RESULTS:

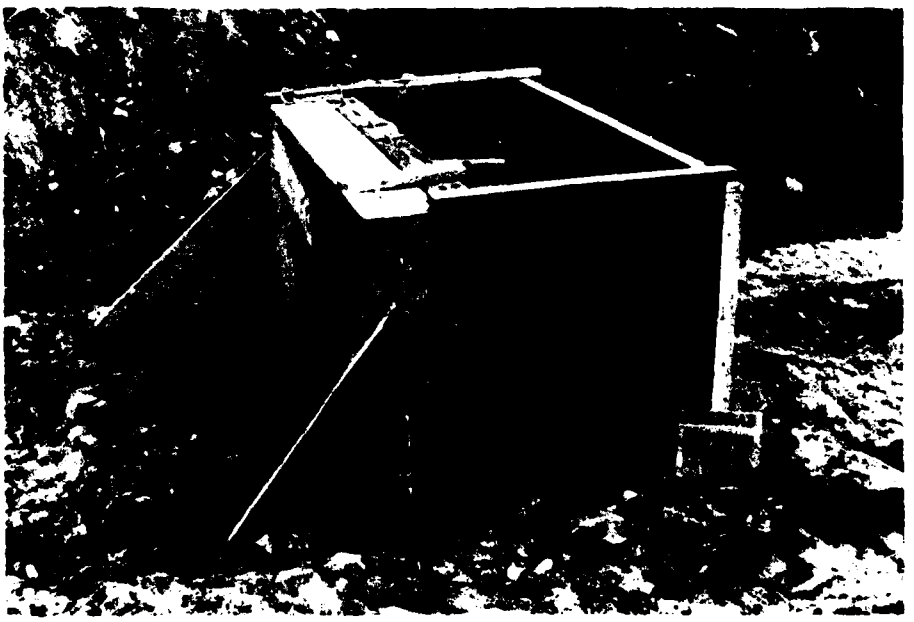
TARGET WALL DISINTEGRATED. WITNESS SHEET RECOVERED WITH NUMEROUS FRAGMENT PERFORATIONS.

Figure 7. Test JBA1201A3

TEST: JBA1201A3
DATE: 1 DECEMBER 1983
TIME: 12:00 MST



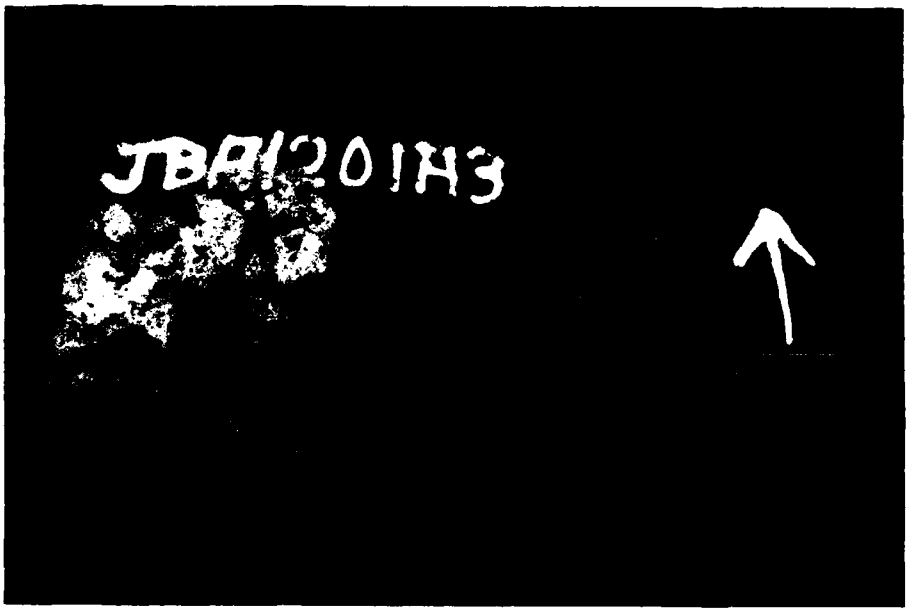
OVERALL VIEW SHOWING SETUP - BEFORE TEST



CLOSEUP OF TARGET WALL AND WITNESS SHEET - BEFORE TEST

Figure 7. Test JBA1201A3 (continued)

TEST: JBA1201A3
DATE: 1 DECEMBER 1983
TIME: 12:00 MST

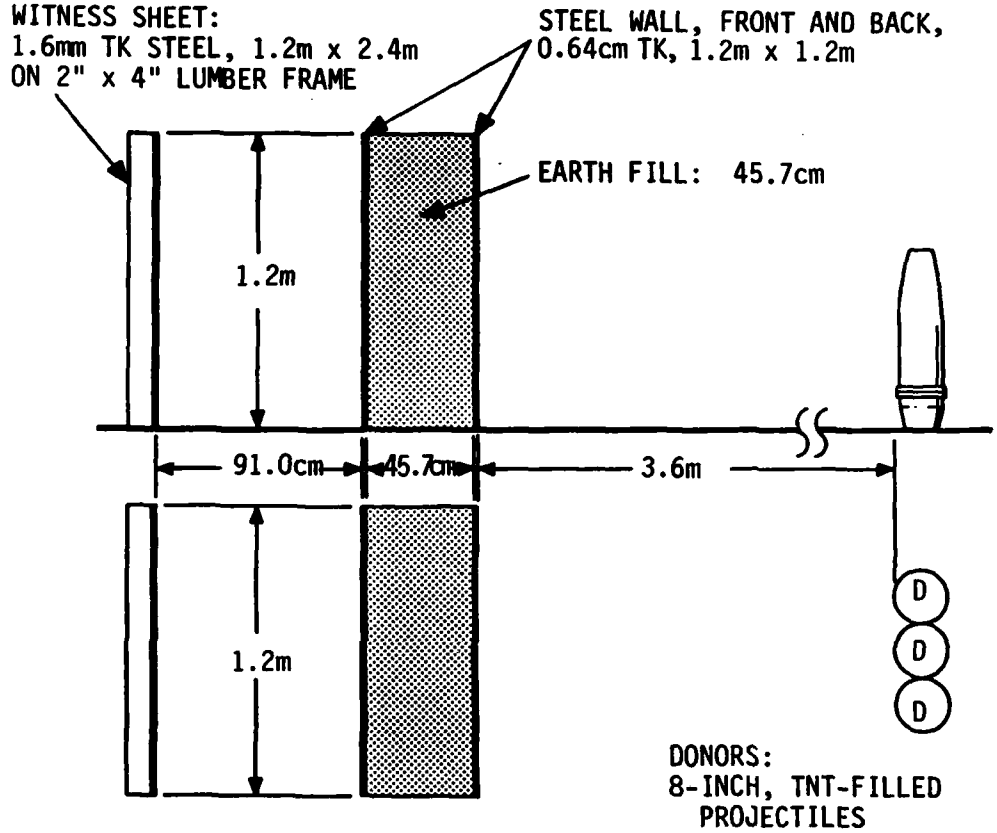


WITNESS SHEET DAMAGE - AFTER TEST

Figure 7. Test JBA1201A3 (continued)

TEST: JBA1201B3
DATE: 1 DECEMBER 1983
TIME: 16:45 MST

MAGAZINE STORAGE TEST



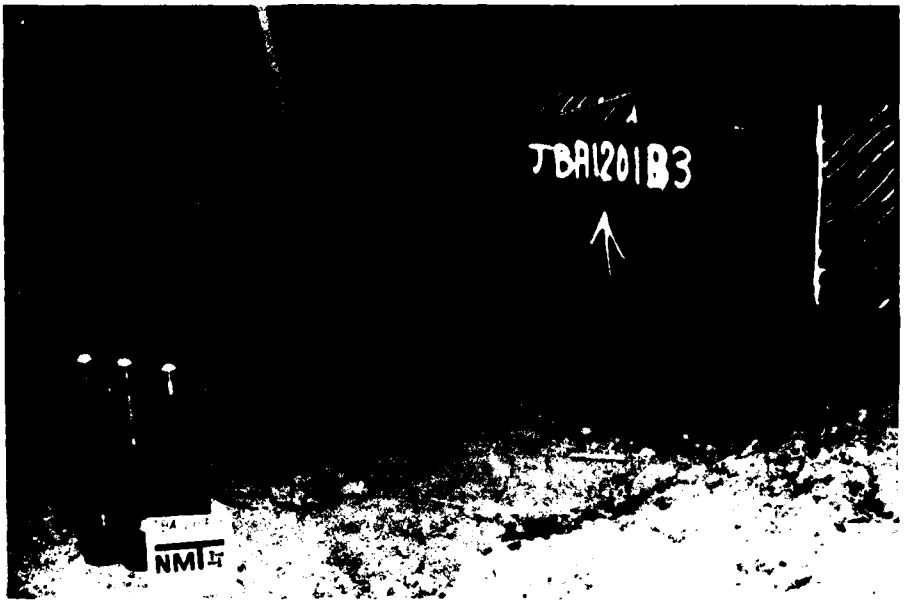
DONORS:
8-INCH, TNT-FILLED
PROJECTILES
8H TNT
LOT #10P-17-115,4-74
D680 CSK-1-180, 1974
8-IN-M106, 3 EACH

RESULTS:

FRONT STEEL PORTION OF WALL RECEIVED EXTENSIVE DAMAGE. BACK WALL HAD ONE FRAGMENT PERFORATION. WITNESS SHEET RECOVERED WITH ONE FRAGMENT PERFORATION.

Figure 8. Test JBA1201B3

TEST: JBA1201B3
DATE: 1 DECEMBER 1983
TIME: 16:45 MST



OVERALL VIEW SHOWING SETUP - BEFORE TEST

CLOSEUP OF TARGET WALL AND WITNESS SHEET - BEFORE TEST

Figure 8. Test JBA1201B3 (continued)

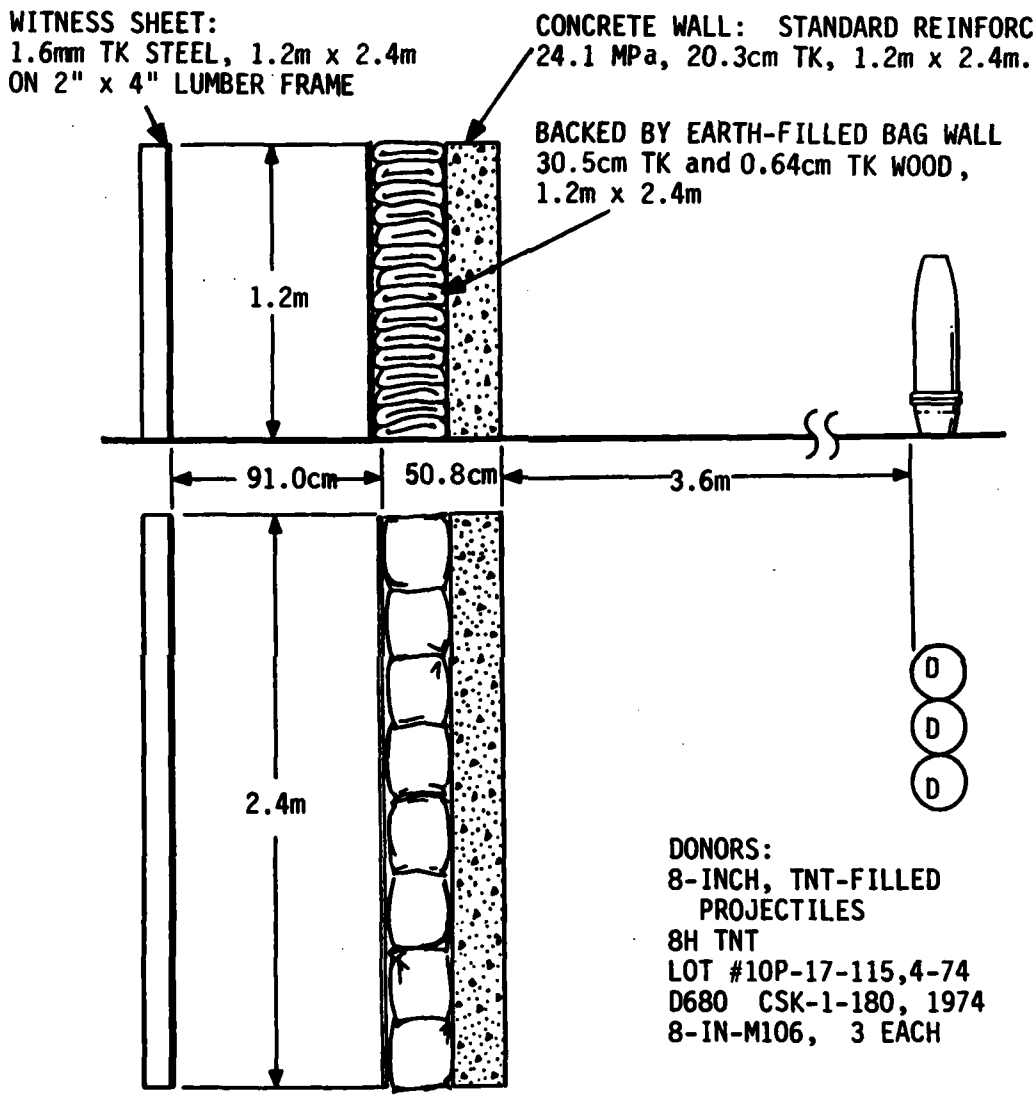
TEST: JBA1201B3
DATE: 1 DECEMBER 1983
TIME: 16:45 MST

WITNESS SHEET DAMAGE - AFTER TEST
FRAGMENT PERFORATION SHOWN BY ARROW

Figure 8. Test JBA1201B3 (continued)

TEST: JBA1202A3
DATE: 2 DECEMBER 1983
TIME: 11:15 MST

MAGAZINE STORAGE TEST

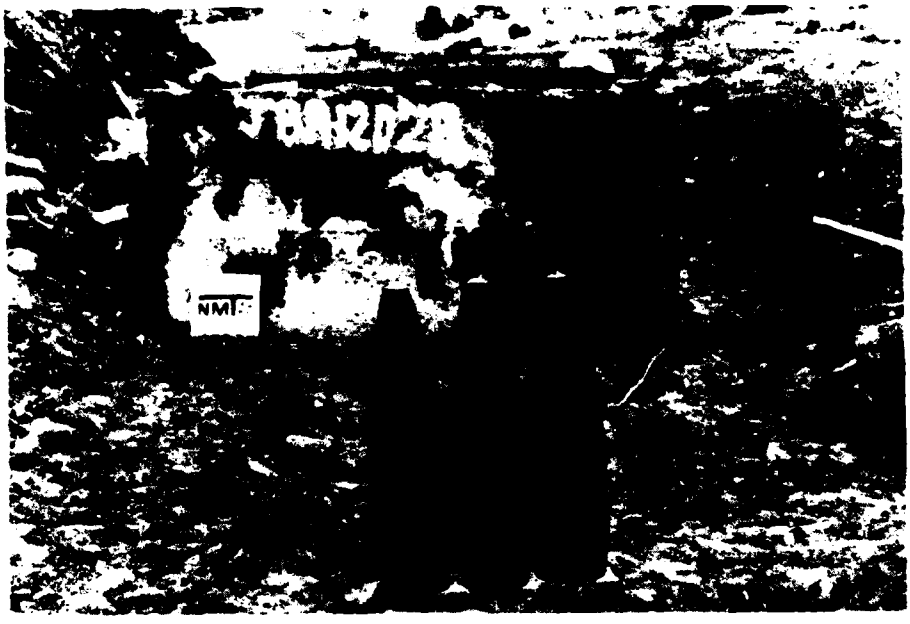


RESULTS:

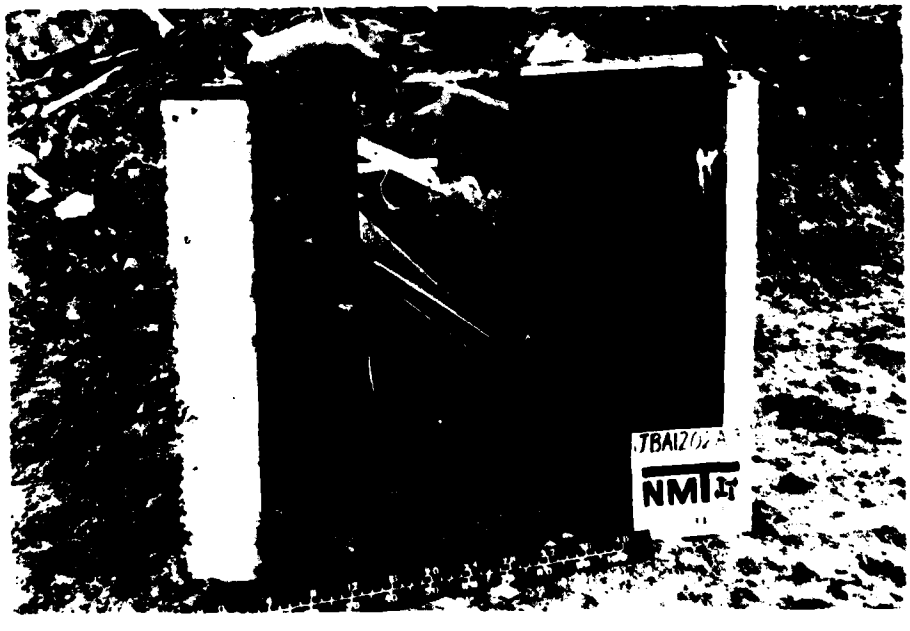
TARGET WALL BROKE UP INTO SEVERAL LARGE PIECES. THOSE WHICH WERE RECOVERED FROM ORIGINAL PLACEMENT OUT TO 22.8m WERE LARGER THAN 5cm IN DIAMETER, WHILE THOSE RECOVERED FROM 22.8m to 53.3m WERE SMALLER THAN 5cm IN DIAMETER. WITNESS SHEET RECOVERED UNDAMAGED.

Figure 9. Test JBA1202A3

TEST: JBA1202A3
DATE: 2 DECEMBER 1983
TIME: 11:15 MST



OVERALL VIEW SHOWING SETUP - BEFORE TEST



CLOSEUP OF TARGET WALL AND WITNESS SHEET - BEFORE TEST

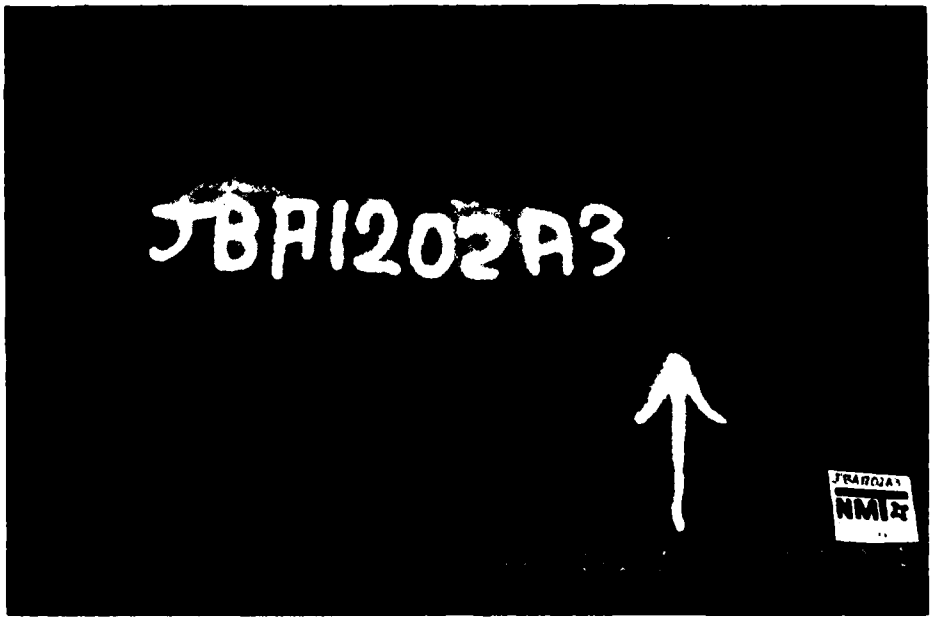
Figure 9. Test JBA1202A3 (continued)

TEST: JBA1202A3
DATE: 2 DECEMBER 1983
TIME: 11:15 MST

CLOSEUP OF TARGET WALL CONSTRUCTION DETAIL - BEFORE TEST

Figure 9. Test JBA1202A3 (continued)

TEST: JBA1202A3
DATE: 2 DECEMBER 1983
TIME: 11:15 MST

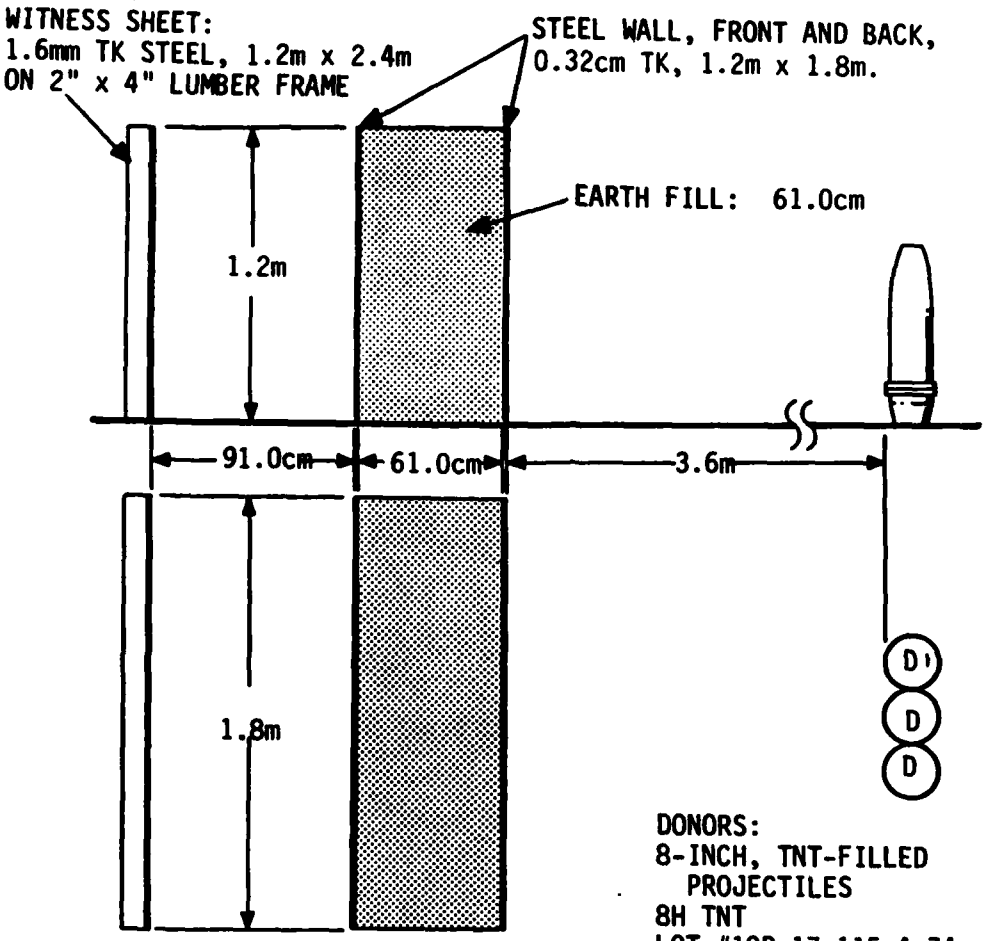


WITNESS SHEET DAMAGE - AFTER TEST

Figure 9. Test JBA1202A3 (continued)

TEST: JBA1202B3
DATE: 2 DECEMBER 1983
TIME: 15:15 MST

MAGAZINE STORAGE TEST



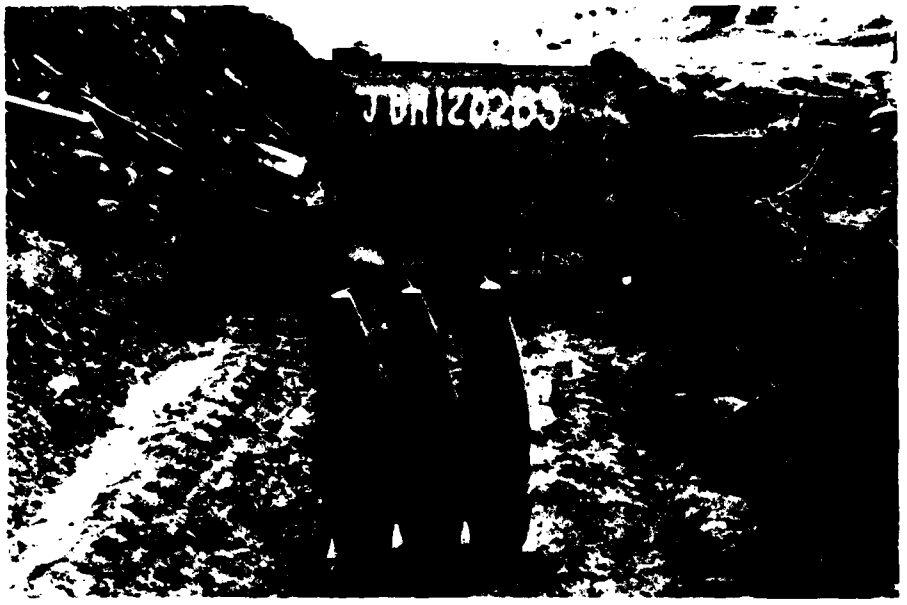
DONORS:
8-INCH, TNT-FILLED
PROJECTILES
8H TNT
LOT #10P-17-115,4-74
D680 CSK-1-180, 1974
8-IN-M106, 3 EACH

RESULTS:

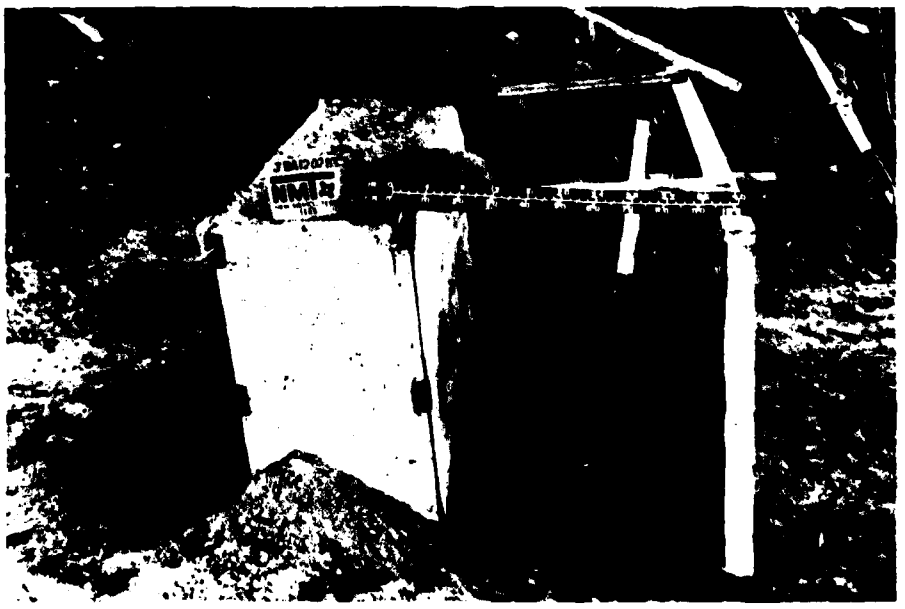
FRONT STEEL PORTION OF WALL RECEIVED EXTENSIVE DAMAGE. BACK WALL HAD ONE FRAGMENT PERFORATION. WITNESS SHEET RECOVERED WITH ONE FRAGMENT PERFORATION.

Figure 10. Test JBA1202B3

TEST: JBA1202B3
DATE: 2 DECEMBER 1983
TIME: 15:15 MST



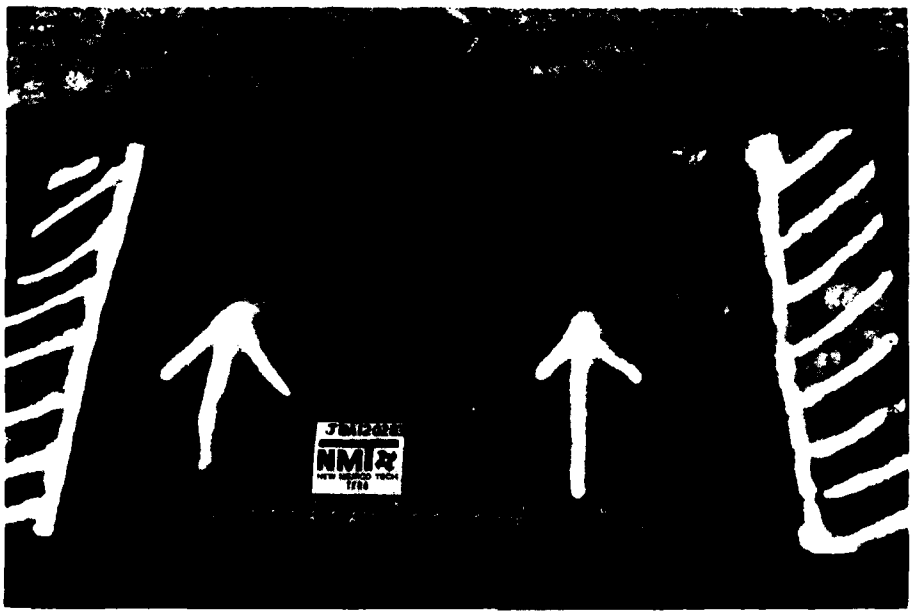
OVERALL VIEW SHOWING SETUP - BEFORE TEST



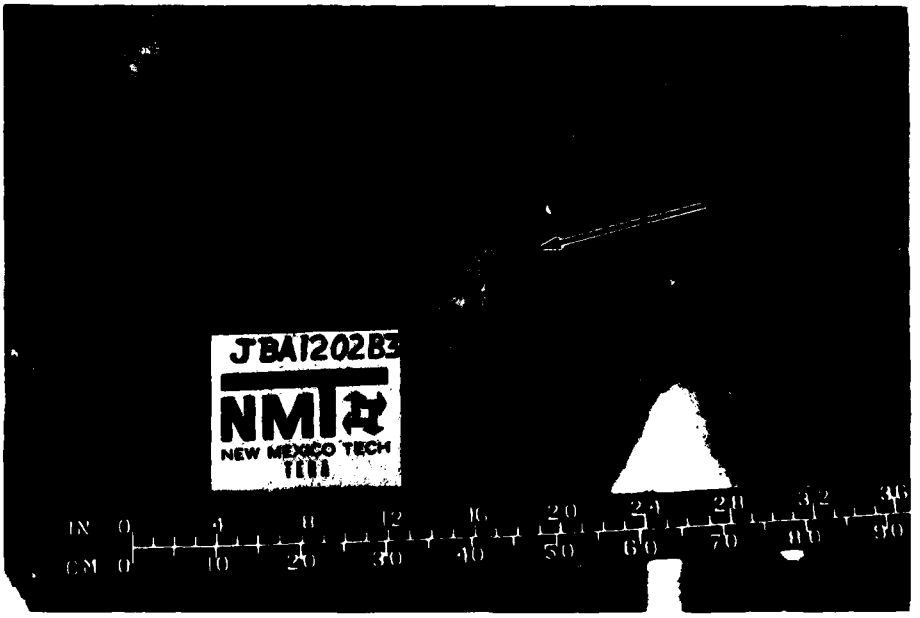
CLOSEUP OF TARGET WALL AND WITNESS SHEET - BEFORE TEST

Figure 10. Test JBA1202B3 (continued)

TEST: JBA1202B3
DATE: 2 DECEMBER 1983
TIME: 15:15 MST



WITNESS SHEET DAMAGE - AFTER TEST



CLOSEUP OF WITNESS SHEET DAMAGE - AFTER TEST
FRAGMENT PERFORATION SHOWN BY ARROW
Figure 10. Test JBA1202B3 (continued)

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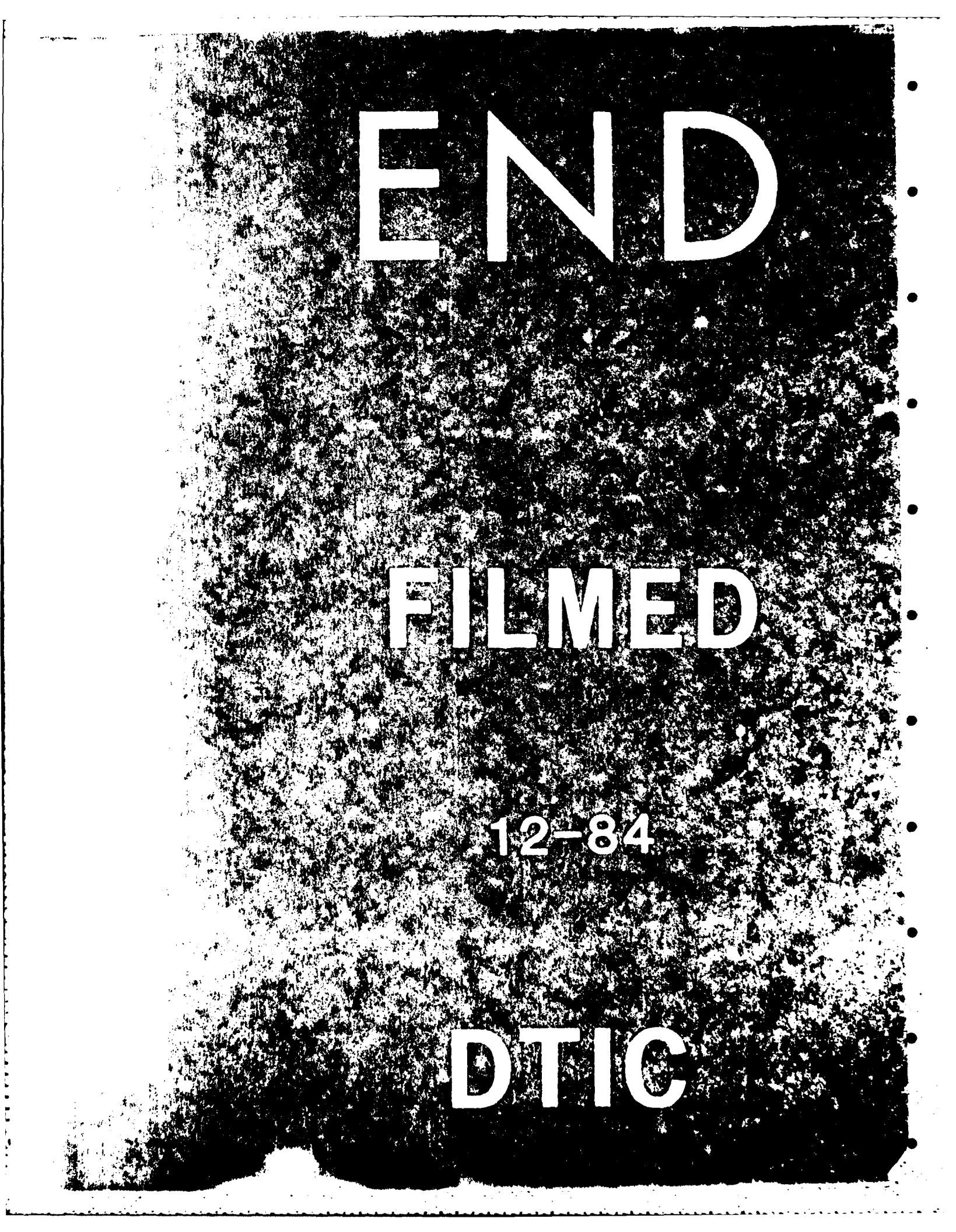
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